Microbiological and Epidemiological Surveillance Programme to Monitor the Health Effects of Foray 48B BTK Spray

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The Ministry of Forests
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Conclusions

- **After an initial period of concern prior to the commencement of the combined spray programme, people called the government telephone hot-line with health related problems with markedly decreasing frequency.**

- **Complaints of asthma, or other respiratory diseases, or complaints of eye, nose or throat irritation were not more common in people living inside the spray zone, nor were they more common in people who were found to be culture positive with BTK.**

- **There was no evidence of an increase in people attending hospital emergency departments during the time of the spray.**

- **People with asthma or other respiratory diseases did not present to emergency departments more frequently during or after spraying as compared to before spraying.**

- **No cases of serious infection with BTK were identified in any hospitalized patients.**

- **Occupationally exposed ground spray workers, frequently developed symptoms of headache, nose, throat and eye irritation, dry skin and chapped lips, but no days of work loss were attributable to BTK.**

- **BTK was repeatedly cultured from commercially available vegetables during and after the spray. People were readily exposed to sources of BTK other than either the aerial or ground sprays.**

Summary

The objective of the microbiological and epidemiological surveillance study was to observe if measurable changes in health occurred during or after the combined aerial and ground spray of Foray 48B, a pesticide that contains Bacillus thuringiensis var kurstaki (BTK). In the process of addressing this question the study has examined the records of more than 26,000 telephone calls, 1140 family practice patients, 3500 admissions to hospital emergency departments, and closely monitored 120 workers with occupational exposure to BTK spray. In addition, the study examined more than 400 bacterial cultures that had been referred in from 10 participating laboratories. In addition we examined samples of air exposed to general concentrations and occupational concentrations of BTK, and samples of food from a variety of times and sources.

The results of this multi-phased study present a wide picture of the Lower Mainland before, during and after the period of aerial and ground spray, and allows some conclusions to be drawn about the impacts of BTK spray on this large urban population.

Although over 26,000 telephone calls were made to the government "MOTH-LINE", only a small proportion related to health concerns. The ranges of complaints were consistent with the problems detected by the Physician's Office Surveillance Programme, and the Ground-spray Workers Surveillance Programme. A marked decrease in the frequency of calls was noted as the spray programme progressed.

The use of the 24 family practice units as sentinel sites provided a representative sample of individuals who attend doctor's offices across the Lower Mainland, and allowed for observing the frequency of complaints in those individuals living within and outside the spray zone. Although many patients complained about respiratory and eye symptoms, we could find no evidence to support that any of the complaints were more frequent in individuals who lived within the spray zone, or in those who had objective evidence of having been exposed to spray. While symptoms may be attributable to the spray, it is not possible to distinguish these from the identical complaints that regularly occur during spring due to environmental factors such as dust and pollen.

There was no evidence to suggest a difference in either the number of people attending an emergency department, or the reasons for attending an emergency department during or after the spray programme.

Concern that HIV positive people or people with other immunosuppressive diseases may be vulnerable to infection with BTK was considered and examined. The examination of all isolates of Bacillus species from all the hospitals and laboratories demonstrated that during a spray period, many people were exposed to BTK. The bacterium was easily recovered from a broad range of body sites. Despite this, when critical specimens including blood, body fluids, and tissues were examined by taking into consideration both the culture result and the patient information, we were unable to find a single case where BTK was a pathogen causing infection. Since all significant cultures collected during the period were examined, we conclude that no cases of infection in immunosuppressed persons have occurred during the time of the spray.

The study provided us with information associated with large occupational exposure to BTK. Although some of the ground spray workers remained culture positive for prolonged periods of time, most individuals remained culture positive for little more than a few days. Almost two thirds of the exposed workers developed some symptoms as compared to a one-third of control group of individuals who were not exposed. Many of the complaints included transient irritative effects such as eye, nose, and throat irritation, dry skin, and chapped lips. Complaints were more likely to develop in individuals who had a prior history of allergies. While a few cases of diarrhea or other gastrointestinal were reported, they were fewer in number than those reported within the control group. Importantly, there were no days of work loss attributable to exposure to BTK.

The information from the ground spray workers may seem to be contradictory to the physician sentinel and the emergency department studies , in that we were more able to detect health effects in exposed ground sprayers. It is important to appreciate that the amount of exposure that these workers had was considerably more than anyone in the general public might experience. Based on microbial air sampling studies that were done, many of the workers had exposures that were 500 times that which the general public

would have experienced, even if they had been directly exposed during an aerial fly-over. Exposure would have been substantially less for individuals who were indoors during and after the spray.

We demonstrated on two occasions that the public is readily exposed to BTK through consumption of commercially available fresh vegetables either organically or conventionally grown.

Although the number of complaints of gastrointestinal disease was small, in none of the cases, either from the ground spray workers, or from the general public where we recovered BTK in the stool did we find any evidence of a history suggestive of food poisoning, or a disease with watery diarrhea similar or suggestive of Bacillus cereus.

The study acknowledges that it did not study all individuals at all times. We have little information on those individuals with pre-existing problems with allergy or asthma who were made unwell by exposure to the spray but chose to not call the government MOTH-LINE, or attend a physician or hospital. Nonetheless it can be said with confidence that no cases of infection were detected in any hospitalized patients, or in any patients studied with bacterial cultures. Finally we found no evidence by examining individuals attending emergency departments that there was any measurable increase in serious community unwellness that could be attributed to the spray.

Background and Introduction

In spring 1992 it was decided by Agriculture Canada and the British Columbia Ministry of Forests that a combined aerial and ground spray programme was necessary to eradicate a recently found cluster of Asian Gypsy Moths in the Lower Mainland of British Columbia. The agent to be used for the programme was a commercial spray product known as Foray 48B produced by Novo Nordisk Bioindustrials, Inc. that contained the bacterium Bacillus thuringiensis var kurstaki (BTK). Although BTK sprays had been used for biological control by both the food and forest industries since 1971, and there was much evidence of its safety with respect to human health, there was sparingly little independent published information on its affects on human health when used to control insects in large urban area. One previous study, reported in 1990, had been laboratory based only, and as such, was unable to address individuals who did not attend a physician, or those who did attend a physician or emergency department but presented with complaints such as allergies, or asthma for which a microbiological culture was not considered as necessary for diagnosis. Also it was not designed to examine for health effects associated with different doses of exposure.

To address the wider aspects of the health effects of BTK spray on a large urban population the following study was developed. The study was done by university based researchers, funded by a grant-contract from the Ministry of Forests. The investigators performed their study independent of Agriculture Canada, Ministry of Forests, and of Novo Nordisk Bioindustrials. By studying many different population groups and environmental factors simultaneously it was possible to develop a wide, and thus reliable picture of the effects of BTK spray.

The body of this report is divided into 6 component chapters that reflect the different populations and targets for surveillance. Each chapter describes a series of experiments that represent one of the areas of focus. Each chapter is structured with an explanatory introduction, followed by a representation of the results of the experiments, which are in turn followed by discussion and interpretation of the results. The final section of each chapter will describe the methods and design of the experiments.

Food and Supplies Microbiology.

Addresses culture of the spray material and food sampling studies during and after the spray period.

Asian Gypsy Moth Telephone Hot-line Surveillance Programme

Monitors the telephone calls made to the government MOTH-LINE as a measure of the health concerns of the general public before, during, and after the spray.

Ground-spray Workers Surveillance Programme

Monitors the health effects of Foray 48B formulation of BTK spray in individuals who had occupational exposure many times more than the dose experienced by general public.

Sentinel Physicians' Offices Surveillance Programme

Monitors individuals who attended a group of sentinel physicians' offices at any time during the period of aerial spray programme, and identifies all health complaints including both infectious and non-infectious concerns before, during and after the spray. This phase of the study examined the frequency at which individuals could be clearly identified as being exposed to aerial spray, and observed for associations between symptoms and exposure.

Medical Laboratory Surveillance Programme

Examines all clinical isolates of BTK recovered from laboratories in the lower mainland during and after the spray period. Through this programme, all individuals, either seen in physicians' offices or in hospitals and suspected of being infected with BTK would be identified.

Lower Mainland Emergency Department Surveillance

Programme monitors admissions to emergency departments to examine for any increased incidence of severe asthma, allergy, or other complaints may be associated with aerial spraying.

Food and Supplies Microbiology

Introduction

During the study, 3 sources of non-patient related samples were microbiologically examined. These included:

1. Foray 48B BTK spray supplied by Novo Nordisk Bioindustrials Inc.
2. Bacillus thuringiensis var kurstaki supplied by Novo Nordisk Bioindustrials Inc.
3. A variety of commercially available fresh vegetables.

The purpose of these studies was to confirm that assays to identify BTK identify detect BTK . In addition these studies would confirm that Foray 48B contained no bacteria other than BTK.

Since BTK is frequently used by the food industry, samples of food were sought to determine whether or not the BTK that were being observed during this study were likely to have come exclusively from the aerial and ground sprays or if it was possible that some may come from other sources. IF BTK was found in foods readily available and probably consumed, then it was possible that some of the isolates may be accounted for in this manner.

Results

No evidence for spray contamination with another bacterium was observed in the sample tested.

In total 14 different vegetable samples were processed. Of the 10 samples cultured by the vigorous swab technique, 5 including 2 separate samples of broccoli, two samples of spinach, and one sample of green pepper, all imported from California were found to be culture positive with BTK. Three of the 5 positive samples were collected from conventional supermarkets while 2 were collected from specialty stores that handle only organically grown produce. The remaining 5 samples including one sample of broccoli, and four samples of lettuce were negative. Of the culture negative samples, one was from California, while the remaining 4 were from British Columbia. When the study was repeated 6 weeks later using the processor method, one sample of California spinach was again found to be positive, while samples of green pepper, strawberries, and tomatoes were found to be negative for BTK, although other Bacillus species were recovered.

Discussion

Culture of Foray 48B was performed because of previous concerns raised about possible contamination of the spray with other bacteria emanating from the environment. No such contamination was observed.

The results of the food phase of the study demonstrated that sources of bacteria resembling BTK but from sources other than the aerial and ground spray programmes were present during the study period. With the methods available it was not possible for us to distinguish the isolates from food from the isolates from the spray. It might be argued that the source of the isolates on the food was from the aerial or ground programmes, however their being found both during and after the spray period, and not on foods that were displayed side by side makes that most unlikely.

These food isolates provide a reasonable alternative to explain BTK in faecal and urinary samples submitted from a broad range of the participating laboratories.

Methods

The Foray 48B spray material was collected by individuals experienced in handling large volumes of material. It was examined microscopically and by culture on a range of selective and non-selective media, incubated both aerobically, and anaerobically for up to 72 hours. All plates were examined for the presence of organisms appearing different from the control culture of known BTK.

Samples of selected vegetables were examined for the presence of BTK. Food microbiology was performed in two fashions, the first by surface swab technique, and the second by a sample destructive technique. With the consent of individual store produce section managers, surface cultures of vegetables were collected by swab in 3 separate grocery stores. In each instance a sterile swab was vigorous rubbed against the surface of the vegetable sample. The swab was then returned to its plastic case and submitted to the microbiology laboratory for processing. In this first phase vegetables were collected from one store that deals exclusively with organically grown vegetables and one store that have a broader range of foods available.

In follow-up to the first study, a second collection of produce samples were purchased 6 weeks after the end of the spray programme, and taken to the laboratory for further processing. In the laboratory, small segments of each sample were placed in sterile plastic bags, and then mashed using a Stomacher processor. Processed samples were then cultured for the presence of BTK, using both PEMBA media that is a selective media for the isolation of Bacillus cereus, and nutrient agar.

Methods used to microbiological identify isolates as BTK were performed in conjunction with known positive isolates of BTK provided by Novo Nordisk and included colony characteristics, demonstration of characteristic spores and parasporal crystal bodies by phase contrast microscopy and an abbreviated biochemical scheme. Cultures were considered to be Bacillus thuringiensis if they produced:

1. spreading colonies
2. beta haemolysis on 5% sheep blood agar
3. oval shaped spores
4. diamond shaped crystals.
5. and biochemically, were lecithinase positive, urease positive, aesculin positive, and failed to ferment mannose.

Sera to confirm identification by serotyping was not available.

Asian Gypsy Moth
Telephone Hot-line
Surveillance Programme

Introduction

To provide a centralized information service to the public regarding the 1992 Vancouver Asian Gypsy Moth Eradication Project, Agriculture Canada established a toll-free telephone hotline in January 1992. A survey was conducted of the health-related calls received between 15 April and 15 June 1992, an interval encompassing the four aerial spray periods.

Results

A total of 26,406 hotline calls were received between 27 January and 30 June 1992 (figure 1). Frequency of calls reached a peak of 15,523 in April 1992, including a high of 1,795 in one day. Only a fraction (8.6%) were health-related, and these reached a monthly maximum of 1,736 calls in April (figure 2). Requests for health risk information accounted for many calls during the weeks preceding the first aerial spray, but as seen in figure 3 the proportion of health-related calls, which reached a maximum of 24% during the week preceding the first aerial spray, dropped sharply after aerial spraying commenced on 18 April, and reached a low of 1% during the fourth spray period.

Of the 19,893 calls received during the period 15 April - 15 June, 939 (4.7%) were health-related. The latter were surveyed, and of 321 calls where information was recorded, 74 were from individuals requesting information only, were from callers outside the spray zone, were unrelated to the aerial spray or were simply protesting the project. The remaining 247 calls represented complaints from individuals who reported being within the spray zone or exposed to spray, and who attribute their symptoms to that exposure; the systems affected are listed in table 1. Seasonal allergy-like symptoms and those of the "flu-like" complex accounted for 36% of these complaints. A further 17% involved respiratory complaints and one-half of these described asthma symptoms.

Discussion

The AGM hotline was particularly busy during April and May 1992, when more than 24,000 calls were logged. However only 8.6% of the total hotline calls, and only 4.7% of calls received in the surveyed interval, were health-related. In the weeks leading up to the first aerial spray, several features critical of the proposed AGM eradication project appeared prominently in the media and may have contributed to the apprehension in many of the individuals who called the hotline during March and April seeking health risk information. The AGM hotline was thus able to provide callers a medium through which concerns could be ventilated, and from which accurate detailed information was readily available. A relatively sharp decline in health-related calls was noted after the spray program commenced, which appeared to reflect the absence of serious medical complications arising from exposure to the spray. Furthermore not all

those who called during the surveyed interval which encompassed all four aerial spray periods were concerned about the effects of the spray. 23% requested only information, and many of those reporting symptoms stated they were doing so only because they understood all symptoms occurring during this project regardless of cause were to be reported to the mothline.

Due to lack of planning time and limited resources only a relative few of the health-related calls were recorded in detail, and no randomly-controlled comparative study was possible. Furthermore no regional baseline data regarding frequency of common symptoms exists, and no information is available regarding either occurrence of symptoms or lack of effects in the vast majority of individuals within the spray zone who did not phone the hotline. Likewise there is no data with which to adequately compare callers, to those individuals living outside the spray zone and not exposed to aerial or ground spray. Although some interesting observations were made in this passive survey, few conclusions can be made from this information regarding the effect of exposure to aerial and ground spray during the AGM Eradication Project.

Methods

During the survey interval telephone calls were fielded by regular hotline personnel, who because of time constraints, found it possible to record details of health-related calls only in the relatively few non-busy periods. None of the operators were health care providers, and none had received special instruction in health-related interviewing, Thus information was gathered in a non-systematic, non-random fashion, and varies in content and in degree of completeness.

In addition to regular personnel, three physicians staffed phones during the three days prior to the first aerial spray and thereafter on spray days to provide specific medical advice and assessment to referred calls.

It should be noted that in this passive survey, callers were self-motivated to report their information and were not matched to controls. Furthermore no comparative study of health effects occuring in individuals living within and outside the spray areas was conducted.

Table 1
1992 Vancouver AGM Hotline: Surveyed
Health-Related * Calls 15 Apr-15 June

Complaint (N = 247)	**Percent**
Seasonal Allergy Symptoms	19
"Flu-like" complex	17
Headache	6
Eyes	2
Nose / Throat	10
Respiratory	17
Gastrointestinal	7
Skin	8
Other (Multiple Systems)	7

* Primary reason for call

1992 VANCOUVER AGM AERIAL SPRAY HOTLINE CALLS

Total Calls: February – June

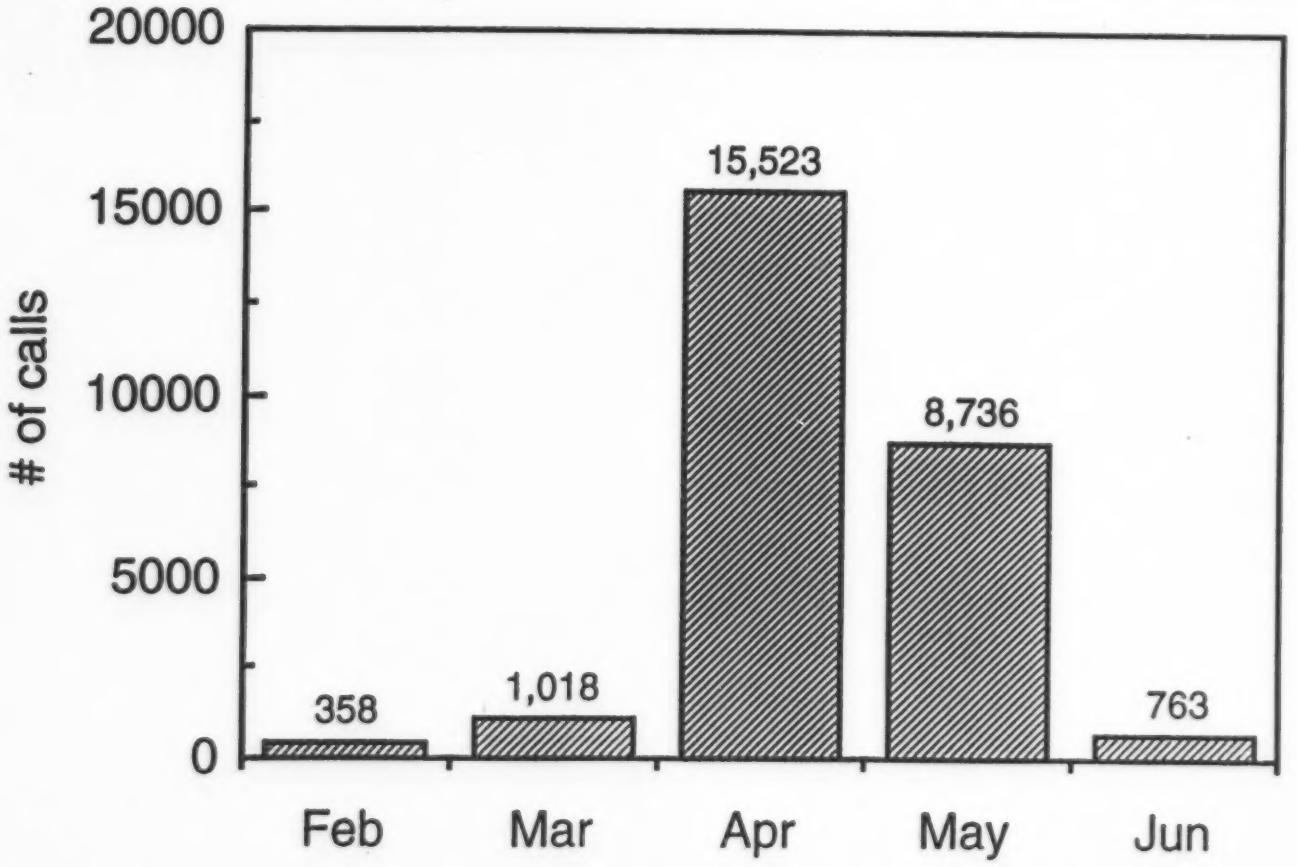

Figure 1

1992 VANCOUVER AGM AERIAL SPRAY HOTLINE CALLS

Health Related Calls: February – June

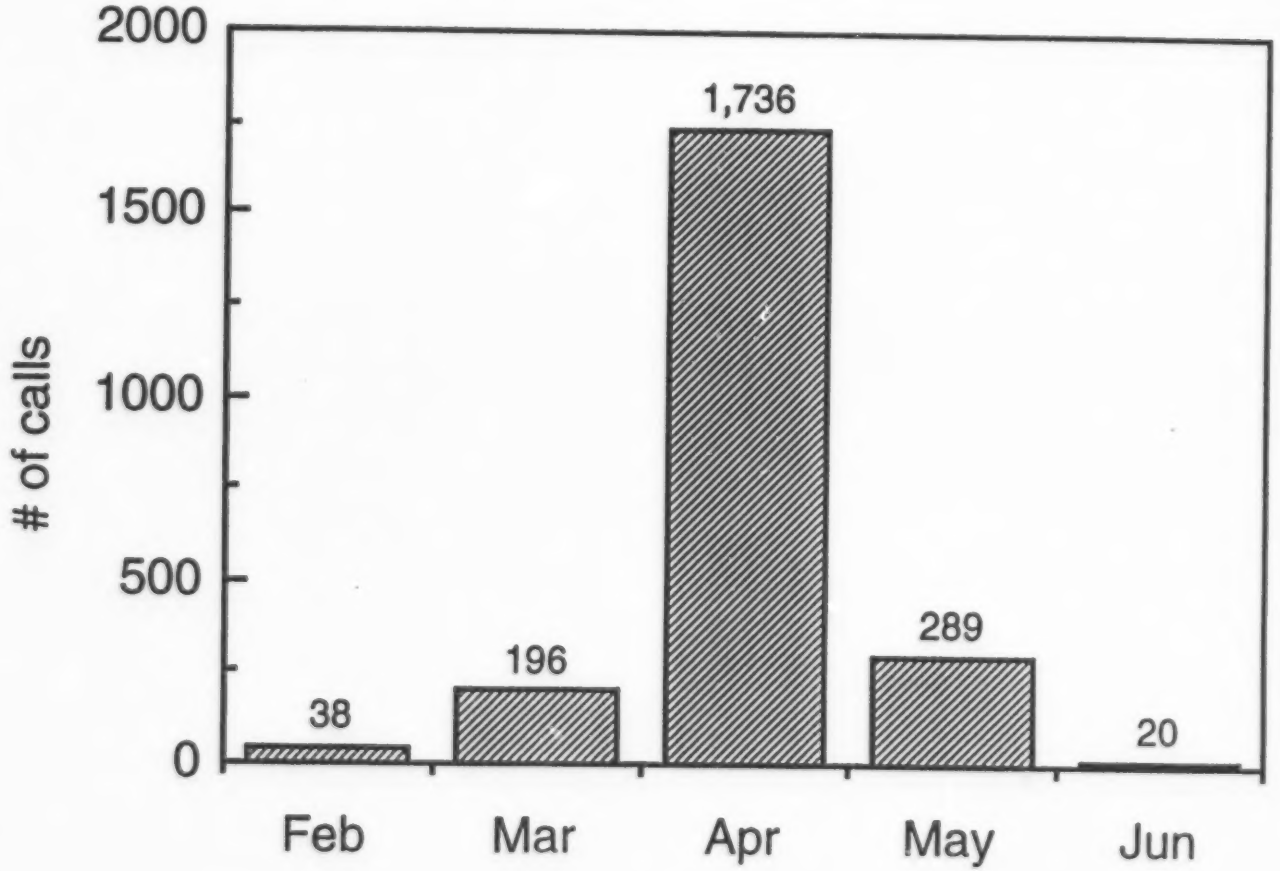

Figure 2

1992 VANCOUVER AGM HOTLINE

Weekly Calls: March – June

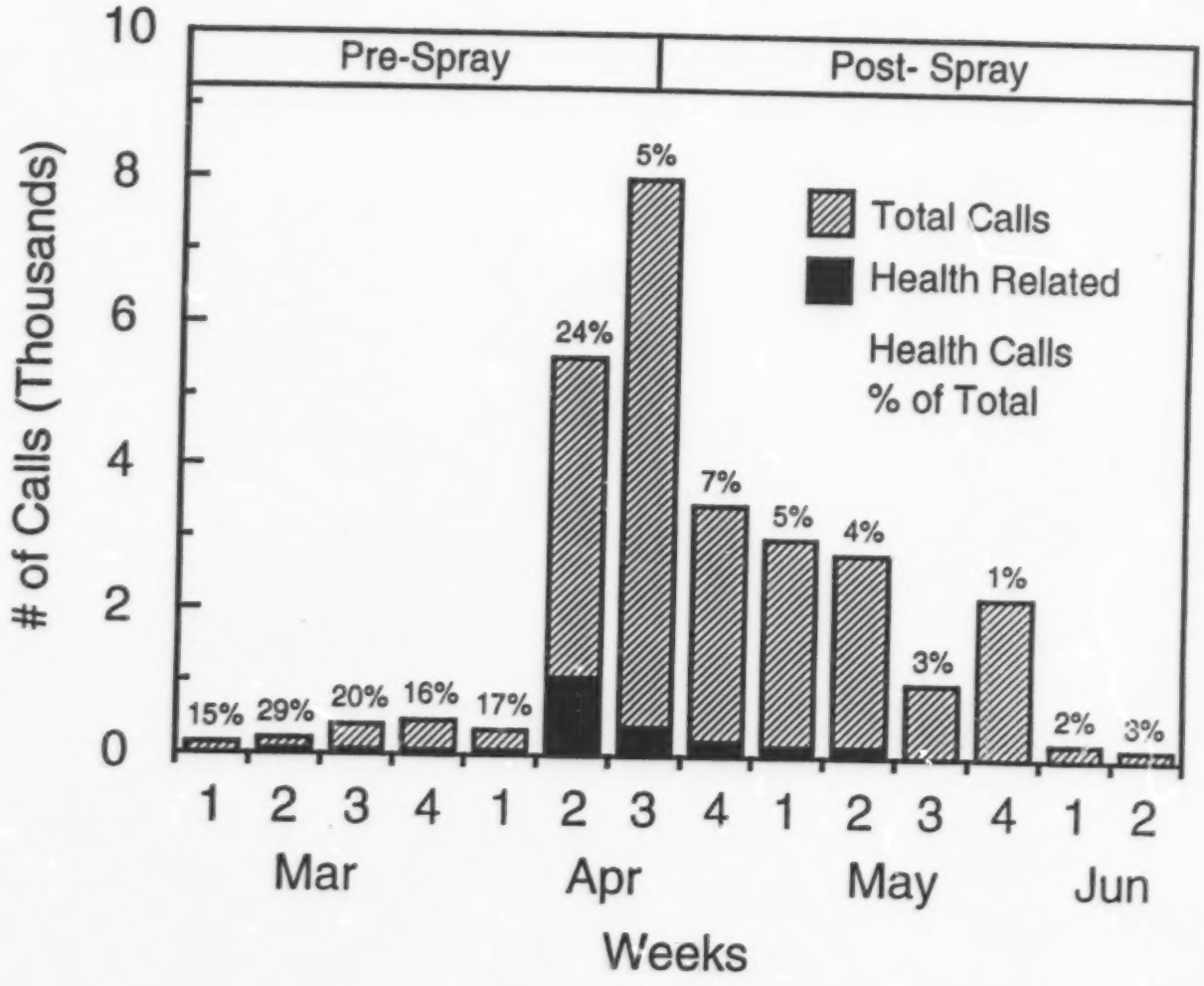

Figure 3

Ground-spray Workers Surveillance Programme

Introduction

Between 18 April and 30 June 1992 the Asian Gypsy Moth Eradication Project Office supplemented the aerial spraying of the biological insecticide Bacillus thuringiensis variety kurstaki (BTK) around the Port of Vancouver, with ground application of BTK to areas at high risk of infestation from the Asian Gypsy Moth (AGM). Approximately 850 hectares of public parkland, residential, and industrial properties were ground-sprayed by licensed pesticide contractors and audited by Agriculture Canada personnel. The commercial BTK product Foray 48B, previously approved by Health and Welfare Canada for aerial and ground-spray application in urban areas, was used.

The objective of this study was primarily to determine if there were adverse health effects associated with the occupational use of the commercial BTK preparation Foray 48B, and secondarily to determine if persistent carriage of BTK occurred in association with adverse health effects.

Results

Populations

The study population, 120 ground-spray workers (GSW) (Table 1), had a higher proportion of males than did the control group (76% vs 59%), had more males in the 20-29 age group, and fewer females in the 30-39 age group. None of these differences were statistically significant. Smoking status was significantly different in the two populations - one third of the subjects were smokers while only 3% of controls smoked. However when smokers and non-smokers were compared regarding frequency of symptoms, no significant difference was evident between the groups. The populations were also similar with regards to pre-existing health status.

Microbial air sampling

Levels of BTK collected by personal monitoring exhibited ranges in keeping with varying conditions and spray patterns. The two cassette readings for an individual were averaged to represent the level in the breathing zone area localized between the cassettes. Results derived from the personal exposure monitoring are displayed in Table 2.

Exposure levels of samples taken simultaneously within a team generally followed a predictable relationship consistent with observed differences in spray patterns or conditions. For example, in a contractor A team the spray operator level usually exceeded four fold that of the auditor, but in a contractor B team only 1.5 fold difference was observed between sprayer and auditor levels. Spraying down from high lifts, spraying low foliage or spraying with prevailing breezes, resulted in lower exposures to spray operators than did

spraying upward into trees. For other team members, proceeding in parallel to sprayers yielded consistently lower readings than did being underneath overhead spraying or following behind the spray crew.

Mean exposure values of the groups ranged from 3,000 to 5.9 million organism spores per cubic meter of sampled air; four of the groups had comparable exposures. It is of interest that public relations personnel who followed crews through the sprayed West-End residential and downtown industrial areas had considerably higher exposure (7 fold) than those preceding the teams, and nearly 2 times higher than their auditors. However because these public relations personnel frequently interchanged positions, their mean exposures become equivalent with those of their auditors.

For those individuals who worked most shifts during the complete spray period, estimated cumulative BTK exposures range from a high of 720 million organisms (sprayers), to a low exposure of 5.4 million organisms (Kromacote card handlers).

Health Effects

Frequencies of adverse symptoms reported in questionnaire #2 by controls and GSW are shown in Table 3; 63% of GSW but only 38% of controls reported adverse health effects (any cause) occurring during the project period . GSW reported symptoms attributable to Foray 48B exposure at frequencies 2-3 times control levels of symptoms in all systems except gastrointestinal and headache which occured less frequently than in controls. Differences are statistically significant. The health effects following Foray 48B exposure appear to be generally transient and irritant in nature; dry skin, chapped lips, eye redness itch and burning, `runny nose' and nasal stuffiness were reported in approximately equal numbers. A number of individuals noted that their symptoms occured only briefly at the beginning of spray periods and when the Foray 48B spray concentrations were increased.

No significant or serious health problems resulted from Foray 48B exposure. Controls reported time lost from work due to illness during the spray period at a mean frequency of 0.16 days per individual and GSW reported an average 0.14 days per person.

Symptoms attributed by the workers to Foray 48B exposure were compared and no significant differences were found with respect to gender or smoking status. History of asthma, seasonal allergies, or eczema appeared to influence the frequency of reported post-exposure symptoms. Only 37% of the individuals with any of these pre-existing health problems (atopic individuals) reported no

effects from exposure to the ground spray, compared to 53% of individuals without allergies, asthma, or eczema. This difference is also statistically significant.

It was found that degree of exposure to Foray 48B spray also influences symptom frequency. As seen in Figure 1 there is a direct relationship between exposure level and reported symptoms. When compared to the low exposure category, a 1.7 fold increase of symptoms is reported in the medium exposure group, and 2.7 fold increase is seen in the high exposure group.

Carriage of BTK

All workers upon joining the cohort provided nose swabs prior to their exposure to ground-spray. Eight Agriculture Canada employees were culture positive on their initial swabbing. All were involved either with dispensing bulk BTK concentrate or recall sniffing from a container of Foray 48B which was opened during an orientation session so that employees could familiarize themselves with the odour of the product. All eight reverted to culture negative status during the project or within 30 days of project completion.

Although not all employees were available during all subsequent swabbing, many were swabbed at all four intervals. Of the 112 workers employed for the duration of the project and who provided at least one nose or throat swab, only 8 remained culture negative; 2 were supervisors intermittently in area of ground-spray activity, and the other 6 were on advance notice teams which were not directly exposed at any time to ground-spray. It was observed that BTK could be recovered from individuals (N=10) who had visited the spray zone for as little as ten minutes, if nose swabs were taken within a few days of exposure but not if taken after a one-week interval since last exposure.

Kromacote card team members were likewise culture positive the day of aerial spray but reverted to culture negative status during the 10-12 day interval between aerial sprays. Nearly all tested workers exposed to higher concentrations for several shifts (5-20) retain BTK for at least 5-6 days and most were culture positive for 14-30 days.

Follow-up GSW results (as of yet incomplete) indicate that few, and usually only those with large and repeated (>4 wk) exposures, retain BTK for longer than four weeks following their last BTK exposure. To date, of the 120 cohort study population, 24 subjects have been unavailable for follow-up culture, and of the remainder, who were swabbed following an interval of 30 to 63 days since last BTK spray exposure, 13 workers yielded BTK from nose swabs but none from throat swabs. All 13 positive on follow-up are male, four had low, and 9 had medium-high exposure levels; 72% of them reported sinus or throat irritation

attributed to Foray 48B exposure. Otherwise no consistent association could be found with regards to age, smoking status, or pre-existing health status.

Discussion

Study & Control Populations

Controls were comparable to subjects in age, gender, prior health history, and working outdoors in areas where commercial pesticides (not BTK) were utilized, but not in smoking status. However smoking was seen not to influence frequency of symptoms within the spray group. The main difference that could possibly influence outcome was that in contrast to the controls, many GSW worked at night and sometimes for double shifts. Length of work day, working outdoors and in shifts was unusual for many and contributed to some of the reported symptoms. Although the workers were asked to differentiate between the effects from Foray 48B spray and from other factors, reporting was subjective and may have been biased toward overestimating effects due to the spray.

Exposure Assessment

Personal monitoring equipment functioned reliably during the study. Dual individual readings proved useful for examining intra-individual differences and in more closely determining breathing zone levels than would have been possible using only one cassette per individual. Relative exposures estimated by observation corresponded closely with those determined by quantitative bioaerosol sampling.

Although the range of exposure levels within groups described in Table 2 is wide, levels of samples collected simultaneously on individuals and within teams were consistent with estimates made during observations of the spray operation, and were generally predictable with regards to relative levels for each team position.

Differences between groups could also be traced to differences in terrain and spray patterns. BTK dilutions were identical, area coverage and high pressure spray equipment was comparable, but contractor A sprayers spent less time spraying downward than did contractor B sprayers. Being exposed to more overhead spraying and having to follow behind the spray operation rather than parallel to it, were the most likely reasons that auditors and public relations personnel working with contractor B crews had higher relative exposures than did their counterparts with contractor A crews.

BTK Carriage

Little information is available in the published literature regarding human BTK colonization following exposure. Nasal swabs were found to be a relatively

sensitive method of detecting recent exposure to ground and aerial spray, but BTK was infrequently recovered from throat swabs.

Methodology necessary to demonstrate colonization as distinct from prolonged carriage was not available during this study. It was therefore not possible to determine whether BTK was recovered from nasal hairs or from nasal mucosa, or if the organisms were recovered in the spore form or in the vegetative state. In this study it was found that in the absence of subsequent BTK exposure, the organism was generally not recovered after an interval of one week following single exposure, but repeated occupational exposure to BTK over several weeks duration appeared to prolong carriage of BTK. Although it is theoretically possible that the BTK organism can persist in spore form for prolonged periods, it can be surmised that positive culture status persisting for more than 30 days after last BTK exposure represents colonization of nasal or sinus mucosa, but this is not proven. Individuals exhibiting persistent BTK carriage are being followed to determine when reversion to culture negative status occurs.

No discriminating features could be found to differentiate those who reverted to culture negative status within 30 days following last exposure to the BTK spray, from those who retain BTK for longer periods. Although the majority of the latter group attributed symptoms of `runny nose' or nasal stuffiness to their exposure to Foray 48B spray, no consistent differences could be found compared to other individuals who reported the same symptoms but who retained BTK for fewer than 30 days. Further information may be obtained from the 24 workers from whom follow-up results are still outstanding.

Health Effects

Quantitative exposures, measured in organisms per cubic meter of sampled air, represent exposure to BTK and also represent exposure to the other components found in Foray 48B. There appears to be a direct relationship between degree of ground spray exposure and frequency of symptoms attributed to that exposure. Most of the complaints, including eye nose and throat irritation, dry skin, and chapped lips, generally appear to be transient and irritant in nature. The Foray 48B label cautions that inhalation or contact with eyes and skin should be avoided but gives no specific information regarding adverse effects which can be expected from exposure to the product. Although certain bacterial cell wall components are known to be irritating and sometimes sensitizing to skin and mucous membranes, no data in the published literature could be found which differentiates what proportion of the observed irritation arises from exposure to the BTK organism, from that, if any, attributable to other components in Foray 48B.

It is not known what reduction of these adverse health effects could have been achieved by the wearing of more protective equipment. Face masks and goggles were not commonly worn for several reasons. Goggles tended to fog quickly which caused significant vision impairment at night and was felt by some to be responsible for a few near accidents. Workers also felt comfortable with the relative safety of the product. The individuals who wore face masks during most of shifts reported no fewer symptoms than the average for their exposure group, but the number of subjects (n=4) is too low for statistical comparison. Personal monitors worn by members of the Kromacote card team during aerial spraying demonstrated that exposures resulting from the occupational use of Foray 48B during the ground-spray program were up to approximately 500 times higher than those to which a member of the general public would have been exposed if outside and directly under aerial spray. Despite the exposure of the ground spray workers to relatively large quantities of BTK organisms (up to 720 million organism spores), no significant health problems were identified, and there were no days of work loss attributable to BTK exposure. This result is consistent with the good safety record of BTK product use over many years in North America.

Methods

Study & Control Populations

Employees from Agriculture Canada, BC Ministry of Forests, Mt. View Tree Service Ltd (contractor A), and Bug Busters Pest Management Inc. (contractor B), involved in the AGM Eradication Project formed a cohort of ground-spray workers (GSW) which was followed prospectively to determine if exposure to BTK resulted in carriage of the organism (in the nose) and was associated with adverse health outcomes.

Volunteer horticulture workers from BC Ministry of Agriculture Fisheries and Food, and students and faculty from Simon Fraser University, Biological Sciences (Pest Management), were included as a control population.

All members of the cohort received a briefing from the principal investigator regarding the study and known medical aspects regarding the BTK organism, signed a voluntary consent form, and completed an initial health survey questionnaire.

This surveillance project was observational only; exposure and conduct of employment (wearing or not wearing protective equipment etc) was determined by employer and employee, in accordance with provincial regulations.

Exposure Estimate

Due to differences in terrain covered by the two contractors, patterns of ground-spray application differed somewhat. Turbulence and wind tunnel effects resulting from uneven building height in the downtown industrial and residential West-End areas necessitated contractor B using mechanical lifts to treat all foliage to the full tree height. Spraying in these areas proceeded in tandem along adjacent blocks, and teams of six (two spray operators, two hose handlers, one record keeper-driver, and a foreman) advanced two high-pressure spray units along each block simultaneously spraying both sides. Two auditors proceeded with the sprayers, and the public relations personnel would both precede and follow behind the crews to control traffic and alert pedestrians. Sprayers and hose handlers would generally trade roles during a shift or on alternate shifts; public relations personnel would likewise exchange front and back positions.

The other contractor was required to spray only to the height reached by high-pressure hoses, and did not exchange positions. Teams consisted of one spray operator, one hose handler and one auditor. The one public relations individual preceded the crew often by several blocks, and was only infrequently required to follow behind the spray operation.

Foray 48B was distributed in bulk, diluted with water, and delivered as a high-pressure spray aerosol. During the first ground spray cycle, a dilution of 200 parts water with 1 part Foray 48B (200:1) was used. During subsequent cycles it was determined that better coverage was achieved when a much finer spray of higher BTK concentration was utilized. During the project, dilutions were reduced to 100:1, then 85:1, and finally 75:1. During the last spray cycle a trailer mounted jet turbine aerosol generator (Rotomister) replaced the high-lift units in the parks and the downtown area.

Relative exposures of workers to Foray 48B were estimated after direct observations were made of each job, and of various contractor teams, types of equipment and spray patterns. Auditor records were kept for each spray unit itemizing exact duration of spraying, area coverage, names, and role of each team member. These records were utilized to ascertain precise duration of exposure to ground spray for each participant in the study.

Quantitative Exposure Assessment

Microbiological air sampling (bioaerosol sampling) was conducted simultaneously within teams. Nucleopore polycarbonate filters sealed in plastic filter cassettes were connected to dual high volume constant flow portable air pumps, and were attached in the individual breathing zone of the worker. Pump

volume and exact exposure time for each individual was recorded. Mean exposure values were calculated and compared for significant differences; jobs having exposures that were not significantly different were grouped, and an average exposure was calculated for that group of jobs.
A team of individuals involved with monitoring aerial spray coverage was also studied. Completeness and density of aerial spray coverage was monitored in part through the use of Kromacote cards which were laid out in predetermined areas and retrieved following aerial spray. The six individuals responsible for the cards were generally exposed to air-delivered aerosol during the fly-over and for the two or more hours it took to collect the cards. Individual breathing zone samples were also collected.

Cumulative individual exposure to Foray 48B was calculated by multiplying the mean exposure value assigned to the individual's job (described above) by the actual hours each worker was exposed to spray operations. Workers were then grouped into three exposure categories (low, medium, and high). Exposure in controls was categorized as nil.

Carriage of BTK was determined by the growth of BTK colonies from nose and throat swabs. Swabs were taken before the ground-spray, at the end of the first spray cycle (12-48 hrs post-exposure), before the third spray cycle (5-6 day interval since last exposure), and following last exposure to BTK (3-5 wks, depending on availability of subject to follow-up); individuals showing persistent carriage received an additional swab approximately one month later.

Adverse Health Effects
Two questionnaires were administered in order to identify adverse health effects. Associations between frequency and type of reported adverse health effects, and prolonged carriage of BTK were examined, and differences were tested for statistical significance.

Table 1

1992 Vancouver AGM Ground-Spray
Workers Surveillance Project
Population Variables

	GS Workers N=120	**Controls** N=29
Mean Age (yrs)	31	34
Smokers (%)	33	3
Non-Smokers (%)	67	97
Male (%)	76	59
Female (%)	24	41
* Atopic (%)	36	39

* Indicates past history of any of Asthma, Seasonal Allergies, Eczema

Table 2

1992 Vancouver AGM Ground-Spray
Worker Surveillance Project
Bioaerosol Exposure *

Position	Samples (No.)	Range	Mean	Standard Deviation
contractor A				
sprayer	8	0.9 - 10.5	5.9	3.3
hose	6	0.6 - 4.0	1.7	2.0
auditor	4	0.5 - 3.2	1.4	1.2
public relations	2	0.6 - 0.7	0.7	0.05
contractor B				
sprayer	30	0.6 - 15.8	3.1	3.1
hose	16	0.2 - 8.3	2.2	2.2
auditor	30	0.4 - 9.6	2.0	2.3
public relations	10	0.2 - 6.9	2.0	2.2
Kromacote card	3	0.2 - 0.6	0.3	0.3

* Bioaerosol Exposure expressed as millions of BTK organism spores per cubic meter of sampled air

Table 3

1992 Vancouver AGM Ground-Spray
Workers Surveillance Project
Post Exposure Effects
(Reported Symptoms, Percent)

Complaint (site)	**Controls** [a]	**Ground-Spray Workers** [b]	
	Total %	Total %	BTK Attributed *
Any Complaint	**38**	**63**	**55**
Skin (Dry Itchy) / Chapped Lips	10	34	25
Eyes (Redness Itch Burning Puffiness)	13	20	19
Headache	10	7	3
Throat (Dry, Soreness)	7	29	22
Nose (`Runny') / Sinus (Stuffiness)	13	27	17
Respiratory (Cough, Tightness)	3	20	12
Digestive (Nausea, Diarrhea)	10	7	4

a Controls N = 29
b Workers N = 120
* (%) = Effects attributed (by the workers) to BTK exposure

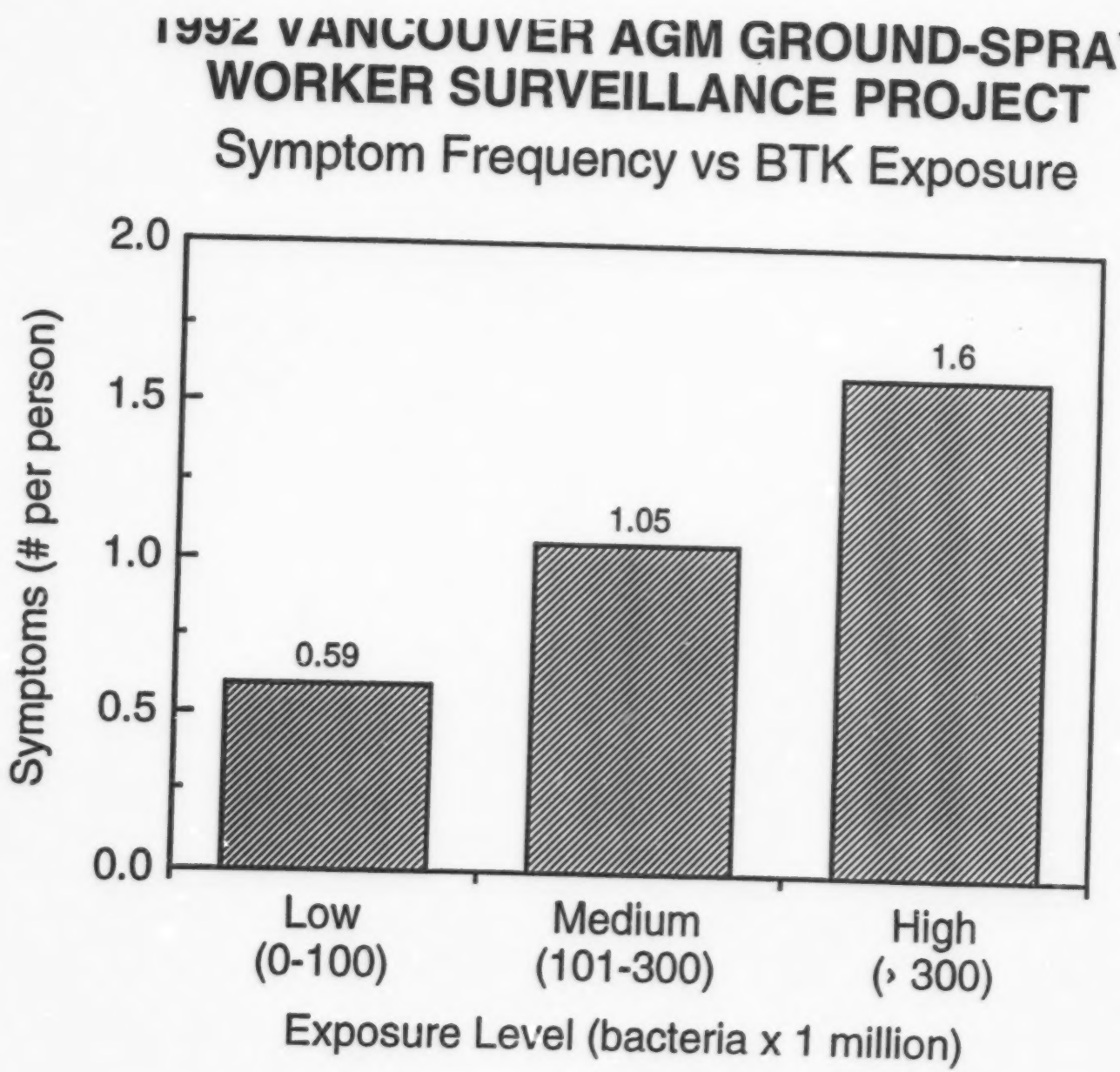
1992 VANCOUVER AGM GROUND-SPRAY WORKER SURVEILLANCE PROJECT
Symptom Frequency vs BTK Exposure
Symptoms (# per person)
2.0
1.5
1.0
0.5
0.0
0.59
1.05
1.6
Low (0-100)
Medium (101-300)
High (› 300)
Exposure Level (bacteria x 1 million)

Figure 1

Sentinel Physicians' Offices Surveillance Programme

Introduction

The physicians' office surveillance programme examined a broad component of the Lower Mainland community to identify those individuals who had been exposed to the aerial spray containing Bacillus thuringiensis var kurstaki (BTK). Demonstration of having been exposed to the spray was sought by testing for the presence of BTK in the individual's nose or throat. Links between being culture positive and having symptoms were then examined. A group of 29 family practice physicians associated with the Department of Family Practice, Faculty of Medicine, University of British Columbia who have their office practices spread throughout a wide geographic area in the Lower Mainland was asked to participate in the study.

Results

Twenty-four of the original 29 physicians were able to participate in the study. One thousand one hundred forty patients were admitted into the study. The number of specimens submitted ranged from 10 to 95 per physician.

Characteristics of the total patients demonstrated a gender ratio females:males of 1.9:1 with mean age for females 38.2 years and for males 36.4 years. The most prominent age group was between 20 and 40 years for both genders. These characteristics are typical of patient populations attending family practice offices.

Postal code information was used to determine if the person lived in or outside the areas covered by the aerial spray programme. Postal codes were available for 1085 (96%) patients , and covered a broad range of postal regions including North Vancouver, West Vancouver, Vancouver, and Burnaby. When postal zone maps were compared against the flight pattern maps, it was determined that 566 (49.6%) of individuals had their residence within the spray zone while 519 (45.5%) lived outside. For the remaining 55 (4.8%) no postal zone was provided.

One hundred twenty eight (11.2%) of the nose specimens cultured from the patients were found to contain resembling BTK. Seventy four (57.8%) were from individuals living within the spray zone, while 50 (39.1%) were from outside the zone. The remaining 4 (3.1%) were from those for whom no postal code information was available. The difference in culture positivity rate for those living within the spray zone (13.1%) as opposed to those outside the spray zone (9.6%) was not significant (O.R.=1.41, 95% CI=0.96-2.06).

A clear timing pattern was noted linking culture positivity to aerial spraying (see figure 1). In each instance, culture positive specimens were tightly clustered around the time of spraying. In each instance, with the exception of the first fly-over, the rate of positivity dropped off on sequential days until it ceased to be detected. With the 4 individual spray periods considered, the longest period of positivity detection following spraying was 5 days.

Neither gender, nor any age group, nor any geographic region was more likely to be culture positive (Table 1).

Reasons for attending the physician are recorded in figure 2. Six hundred seventy five were either asymptomatic or had symptoms unrelated to the spray. The remaining 465 (40.8%) had symptoms including allergies, asthma, rhinitis, conjunctivitis, otitis media, sinusitis, headache, pharyngitis, upper or lower respiratory tract infection, shortness of breath or skin rash. No individual symptom group was more likely to be culture positive when compared against the rate in asymptomatic individuals. Because of the design of this phase of the study, it is not possible to determine with certainty if any of these symptoms were more common in those living inside or outside the spray zone, however, it was noted that for those for whom postal code information was available, and a possible complaint was noted, 240 (54.1%) were from those living within the spray zone, and 204 (45.9%) were from outside. This proportion was markedly similar to the proportion of individuals living inside and outside the spray zone strongly suggesting that possible complaints were no more likely in those living inside the spray zone, as compared to those living outside.

A follow-up letter was written to each physician to make inquiries about each of the patients with a positive culture. It was noted that 19 of 128 patients with BTK (14.8%) were treated with antibiotics as were 167 of 1012 patients without BTK (16.5%). None of the patients with BTK had a negative outcome even though 119 (85.3%) had received no antibiotics, and of the 19 who did, 6 who had been started on antibiotics to which the organism was highly resistant. Of the 19 patients with BTK who had been started on antibiotics, 9 lived within the spray zone, 10 did not. Four had been started on antibiotics prior to the onset of the spray programme. No link between diagnosis, possible exposure to BTK, and decision to prescribe antibiotic therapy could be identified.

Discussion

The results of the physicians' office surveillance provides information about the ease in which the nose was able to trap BTK suspended in air, and also the short duration of nasal carriage of the organism, and also the lack of any apparent relationship between the timing of the spray and the types of complaints presenting in the physicians offices. There is little indication that BTK was associated with significant infection considering that the vast majority either of people did not receive an antibiotic, or if they did, only one third received an antibiotic to which the organism would respond. If infection was present, it would have had to have been brief and self limited.

The difference in pattern for positive cultures during the first fly-over may have been the result of the intermittent days of flying as opposed to the sequential flying days of the other periods.

The lack of association between the nose cultures being positive and the postal code information suggests that either the tests used for microbial identification were sufficiently non-specific to ensure that the organisms were all the same, or other factors such as location of work, occupation, or location at the time of spraying also play a role in whether or not an individual could become exposed to the aerial spray. Because serotyping of strains was not available, the former is a distinct possiblity; however,the clear timing of positives with the timing of the aerial spray-overs strongly argues for the latter.

Methods

The physicians were requested to enroll the first five patients to come to their office during the five days prior, during and after each spray period, regardless of their symptoms or complaints, and in addition to collect swabs from any patients who came up to 10 days after each period with any symptoms "of interest" that may be related to the spray including respiratory infection, pharyngitis, asthma, allergy, sinusitis, conjunctivitis or rash. The physicians would test for the presence of BTK by swabbing either nostril for bacterial culture. In addition, if a significant infection was thought to be present, a second culture would be sent to a medical laboratory as a method for clinical detection.

To ensure timely processing of cultures, and information, all materials were collected and transported by study personnel to the Microbiology Laboratory of University Hospital, Shaughnessy site. All swabs were accompanied by a form providing the person's age, postal code, symptoms, diagnosis, and whether they were to be put on antibiotics.

Swabs were tested by standard culture techniques using 5% sheep blood agar and nutrient agar. Cultures were identified by typical colonial morphology, and were confirmed as Bacillus thuringiensis by characteristic spore and crystal morphology. Bacillus thuringiensis strains were defined in conjunction with 2 known postive strains of BTK using an abbreviated biochemical scheme. Strains were defined as BTK if they were beta-haemolytic, lecithinase positive, urease positive, aesculin hydrolysis positive and failed to ferment mannose. Serotyping was not available at the time of the study.

Information and culture results were encoded in a computer database software programme and were analyzed by comparing the numbers of those with symptoms of asthma, allergy, respiratory symptoms, conjunctivitis, or rash against those who were either asymptomatic or were presenting with unrelated complaints. Variables examined included, patient characteristics (age, gender), home postal code as a measure of whether their place of residence had been exposed to spray, date of onset of complaints and date of presentation at their physicians' office. Tests of statistical analysis including odds ratio, or chi-square analysis were applied to group differences in order to determine if differences were sufficiently large to not have occurred by chance alone.

Table 1

Physicians' Office Surveillance Programme
characteristics associated with culture result

		Culture Negative	Culture Positive
Gender *			
Male		333 (86.5%)	52 (13.5%)
Female		659 (89.9%)	74 (10.1%)
Residence Location *			
Inside spray zone		492 (86.9%)	74 (13.1%)
Outside spray zone		469 (90.4%)	50 (9.6%)
Age *			
range (years)	0- 20	148 (85.5%)	25 (14.5%)
	21- 60	668 (88.9%)	83 (11.1%)
	61-100	159 (90.9%)	16 (9.1%)
mean (years)		37.9	36.1
"Of interest" symptoms reported **			
Yes		425 (91.4%)	40 (8.6%)
No		587 (87.0%)	88 (13.0%)

* **Block does not include all 1140 cases, because some data not provided.**

** **See Text for definition of "of interest" symptoms**

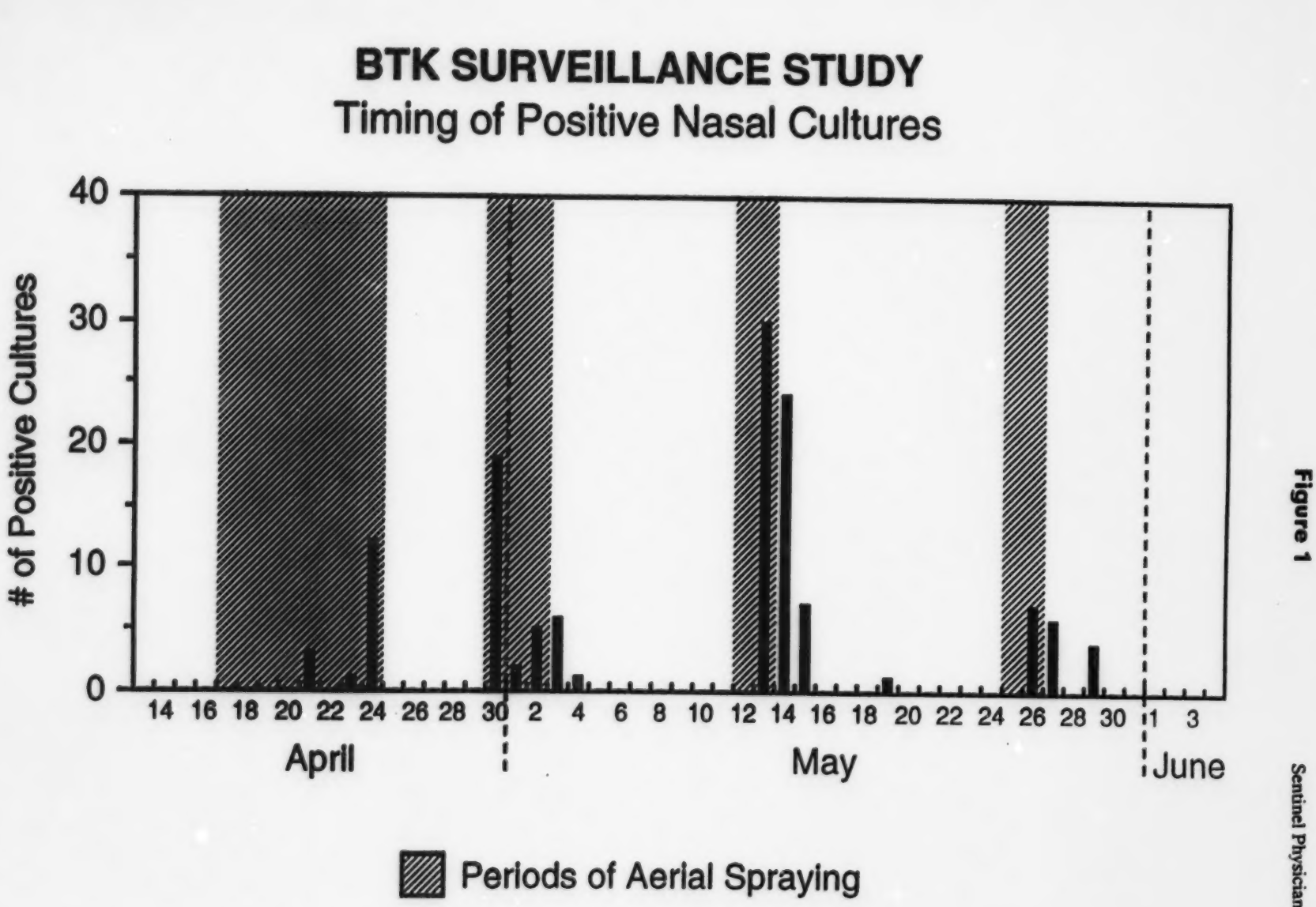
BTK SURVEILLANCE STUDY
Timing of Positive Nasal Cultures
# of Positive Cultures
40
30
20
10
0
14 16 18 20 22 24 26 28 30 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 1 3
April
May
June
Periods of Aerial Spraying

Figure 1

PHYSICIAN SURVEILLANCE PROGRAMME

Complaints Reported: April 13 - June 4, 1992

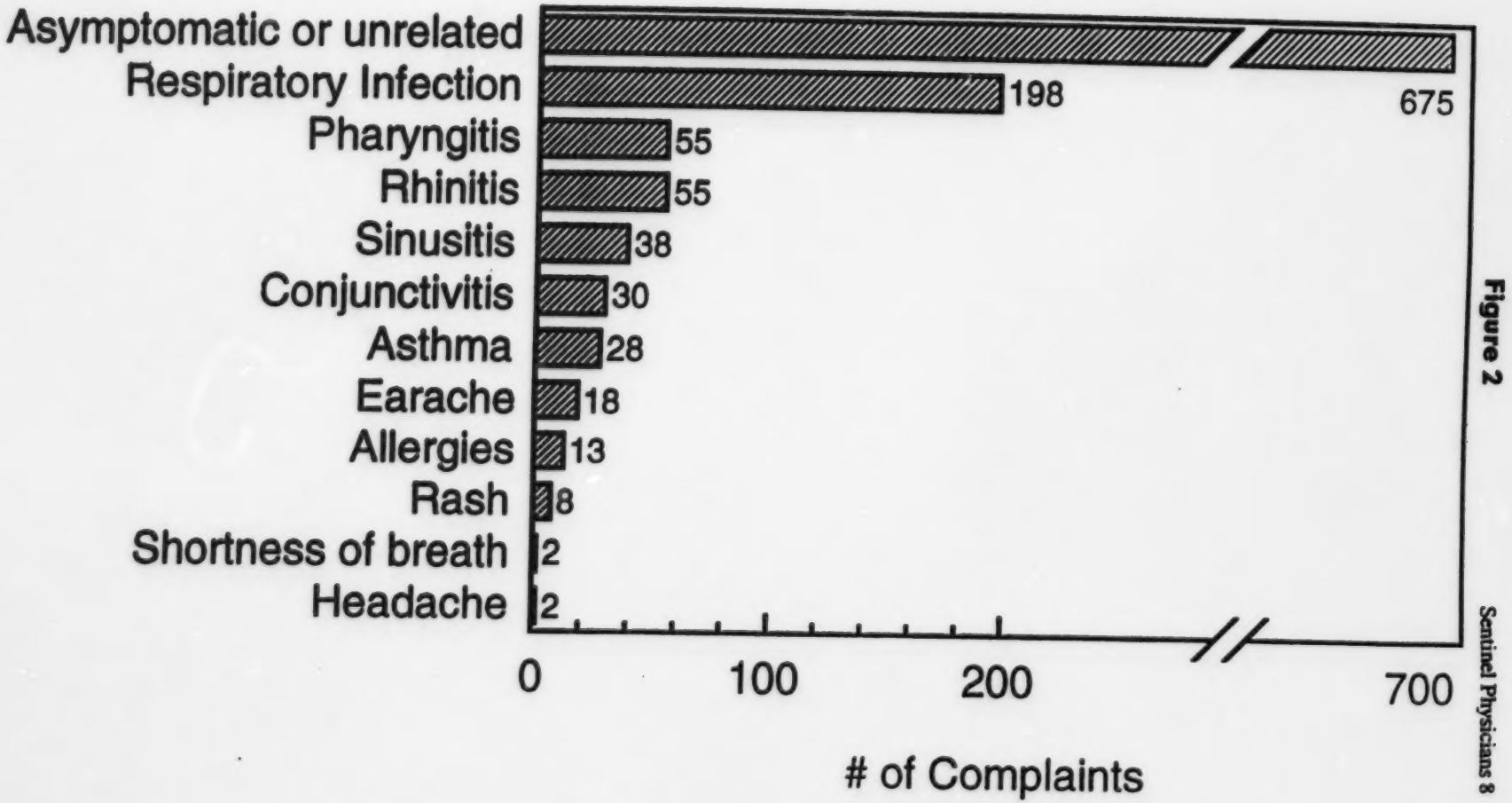

Figure 2

Sentinel Physicians 8

Medical Laboratory Surveillance Programme

Introduction

The objective of the laboratory surveillance programme of the study was to capture and identify all isolates of BTK recovered from any patient in the Lower Mainland who presented to a physician either in an office practice or in a hospital with sufficient symptoms that a specimen was collected which would identify a possible infection. This would provide an index of those patients who had developed a clinical infection associated with BTK.

Results

Through the cooperation of Lower Mainland laboratories, 429 bacterial isolates were submitted for analysis. Three hundred twenty-five (75.8%) isolates were characterized as BTK. In 43 of these 325 cultures (13.2%) BTK was recovered in pure culture. I n 42, the growth was characterized as light. In 1, it was characterized as heavy. Further clinical information was sought on the patients for these 43 cultures. Along with these cases, information was sought for 2 invasively collected specimens, one body fluid, and one tissue biopsy, both which had mixed culture results. Information was available for 37 of the 45 cases (82.2%).

Seven isolates were recovered from blood cultures or intravascular lines. Following close examination of each case, in none of the cases was BTK the causative agent of patient's unwellness. In two of the 7 cases, the patient had a rapid recovery while treated with an antibiotic to which the bacterium was highly resistant. In two the patient had a transient mild fever episode, which resolved although neither was treated with antibiotics. In 1 case, the culture was collected as a test of cure following completion of antibiotic therapy given in hospital for a previously well documented bacterial infection involving a different organism. When the culture was collected, the patient was feeling well, without fever or any other signs of infection. He was discharged from the hospital the next day. In the remaining 2 cases, swabs for microbiology cultures were taken of 2 intravascular lines at the time of their removal. In both instances, culture of the swab was found to contain BTK even though the patient was afebrile and feeling well, and discharged from hospital. In neither case was BTK or another Bacillus species recovered from cultures prior to removal of the

lines. It was determined that in all of these instances, the BTK was coincidental and probably represented skin contaminants either from the patients themselves or from hospital ward or laboratory staff.

Two specimens were from tissue biopsies. In one, the BTK was found to be coincidental to a definite diagnosis of viral infection. In the other, the organism was from a patient in whom infection was not the suspected diagnosis, and an alternate definitive tissue diagnosis was made. In each instance the organism was from broth culture only, and was suspected to represent a coincidental contaminant.

In 3 patients BTK was recovered from an aspirated body fluid, one from a knee, one from pleural fluid, and one from peritoneal fluid. In none of the cases was bacterial infection considered to be the clinical diagnosis. In each instance, the culture was found in broth culture only, and was interpreted as a coincidental skin contaminant.

Thirteen of the pure culture isolates came from genital-urinary cultures. Of 12 urine cultures, 6 were from symptomatic patients and 4 were from patients with screens for asymptomatic bacteriuria. Of the symptomatic patients, 3 improved without antibiotic therapy, 1 improved while receiving antibiotics to which the organism was highly resistant. One of the remaining two had onset of symptoms 4 days before the onset of spraying. The other lived, far outside the spray zone. Of the asymptomatic patients, one culture was positive while the patient was on doses of an antibiotic to which the organism was highly sensitive, and therefore, most likely represented a skin contaminant rather than true pathogen. The other was not treated, did not develop into symptomatic disease, and was not found to be positive on a subsequent culture. The single patient with a culture found to be in heavy pure growth was a woman with symptoms compatible with a urinary tract infection, however all symptoms resolved without antibiotic therapy. One individual was found to have light pure growth cultured at the time of a gynecological procedure. Infection was not a considered diagnosis. Clinical information was unavailable for 2 patients with light pure growth in urine cultures.

Ten of the pure culture isolates came from cultures of eyes. Two patients had symptoms resolve while on common eyedroppers that contain antibiotics to which the organism is sensitive. Neither patient had related their unwellness to spray exposure. A third patient did not respond to antibiotic therapy to which the organism was highly sensitive. A non-infectious diagnosis was made by a consultant ophthalmologist. The patient responded to appropriate therapy. The remaining patients had symptoms resolve without antibiotics. Clinical information was unavailable for 2 patients with light pure growth in an eye culture.

Nine of the pure positive isolates came from skin cultures. Clinical information was available for 5, all of which were of doubtful clinical significance. The sites included neck, hand, foot, chest. In each a non-infectious alternate diagnosis was considered, and in each situation, the problem resolved without antibiotics.

In one case, a couple was exposed to ground spray while cycling. Both experienced facial moisture but no discomfort. A nose culture collected the day following exposure from one, and was found to grow a pure and heavy growth of BTK. No culture was collected from the other. No infection of inflammation developed in either person. Neither was treated with antibiotics.

Along with information taken from patients with pure culture results, additional information was also sought by standardized questionnaire from the attending physicians on 16 patients with positive faecal cultures. The questionnaire asked specifically about symptoms and associations with foods. Information was available for 12. Eight of the patients had transient diarrhea, while 4 were collected from patients without diarrhea for other reasons. One patient was noted to have a known bacterial enteric pathogen and 3 had known enteric parasites. No pathogens were identified in any of the others. With the exception of one patient, who associated symptoms with curried chicken, no associations with any particular foods were noted. No patient related their symptoms to contact with either aerial or ground spray. No information was collected on a control group of patients.

Discussion

Because all laboratories in the Lower Mainland participated in this phase of the study, any true infection that occurred during or after the spray period and was made by documented culture would have been captured by the study. For that recson it was determined that the population at risk would be the total population of the Lower Mainland. Prior census data has reported the population to be approximately 1,400,000.

While information was not available on all cases where BTK was recovered, it is important, that all cases where blood, body fluids, biopsies, and intravascular lines were investigated. No cases that fit the study criteria for infection were found. In this regard, the results of this phase of the study are markedly similar to those reported from Oregon, where the vast majority of positive cultures were thought to represent culture contaminants, or at most, minor local site infections.

Concern that HIV positive people or people with other immunosuppressive diseases may be vulnerable to infection with BTK was examined indirectly. All isolates of Bacillus species recovered from all hospitals and laboratories during the period of the spray programme were examined by the study laboratory. Despite this, when all critical specimens were examined from both clinical and laboratory perspectives, we were unable to find a single case where BTK was a cause of infection. Since all significant cultures collected during the period were examined, we conclude that no cases of infection in immunosuppressed persons have occurred during the time of the spray.

The large number of positive enteric, genital and urinary cultures was noted. The possible source for these positive cultures all represent coincidental contamination from the collection or processing of the cultures. It is also possible that they represent true enteric isolates that have successfully passed through the gastrointestinal tract, and have become part of the genital flora. To definitively answer these questions, one would require further study.

It is important to appreciate that the recovery and identification of most of these positive cultures occurred only as a result of the laboratories' cooperation with this study. In most instances, the presence of occasional Bacillus species colonies in urine, faecal, or skin cultures would be overlooked as an inconsequential component of mixed normal flora. For this reason, it is not possible for the study to say if the enteric, faecal, or skin isolates detected at this time represent any change from normal findings.

It is appreciated that the absence of infection does not exclude cases of irritation that may have occurred because of contact with spray. Indices of irritative symptoms were monitored through the BTK ground-spray workers, Physician's Office and Lower Mainland Emergency Department Surveillance Programmes.

Methods

All Microbiology Laboratories receiving specimens in the Lower Mainland were asked to assist with the study by providing all isolates of Bacillus species recovered from clinical specimens for species identification, and to provide information including the site from which the specimen was recovered, the amount of Bacillus in the specimen, whether the Bacillus isolate was recovered in pure culture, and if not whether it was associated with normal flora for the site, or associated with a known pathogen. All isolates were referred to University Hospital UBC site where each isolate was identified. The methods for identification were the same as those described in the physicians' office surveillance programme.

For those isolates identified as BTK recovered either in pure culture or in heavy amounts, additional clinical information was sought in order to determine if the culture was likely to represent an infection with BTK. In accordance with ethics approval by the University of British Columbia, a letter was written to the ordering physician requesting information on the clinical case. The letter was followed by a telephone conference with a registered nurse associated with the study.

The definition of infection used for the purposes of this study included the following criteria:

1: the patient presented with signs compatible with an infection

2: BTK was recovered either in pure culture, or in heavy concentration in the absence of a known pathogen

3: If the patient was treat with an antibiotic, the outcome of the infection was consistent with the expected result based on sensitivity testing. The infection would not be expected to respond to an antibiotic against which BTK was highly resistant, but would be expected to respond to one to which BTK was sensitive.

Table 1

Sites from which BTK was recovered

Site	Pure Culture	Mixed Culture	Total
Genital	1	55	56
Urine	12	22	34
Eye	10	17	27
Faeces	0	16	16
Leg-foot-toes	1	10	11
Head-neck	1	8	9
Chest-abdomen-back	3	6	9
Arm-hand-fingers	3	6	9
Skin (not specified)	1	5	6
Nose-throat	1	7	8
Sputum	0	6	6
Blood	5	0	5
Body Fluids	2	1	3
Biopsy tissues	1	1	2
Intravenous lines	2	0	2
Total	43	160	203

Lower Mainland
Hospital Emergency Department
Surveillance Programme

Introduction

Visits to the Emergency Departments of six hospitals in the Greater Vancouver region for the period April 13, 1992 to June 4, 1992 were reviewed as an indirect measure of serious unwellness that may have developed in the community as a consequence of the aerial spray of Foray 48B.

Results

Six Emergency Departments and hospitals gave permission for the research assistants to come into their departments, review records and abstract the information. Five of the departments were either within the spray zone or bordered the spray zone. The sixth department was more removed from the spray zone but nonetheless did have patients whose home address was within the spray zone.

Over this 53 day interval, spraying occurred on 12 days. Four of the 12 spray days and 11 of the 41 non-spray days (including Victoria Day, Monday May 18) were weekend days. Seven of the 11 non-spray weekend days occurred in the post spray interval.

The total number of visits to the six emergency departments was 33,636. The pattern of visits is diagrammed in Figure 1. The average number of visits on each day was 634.6 with the range extending from 457 to 807. The maximum number on a spray day was 732 and the minimum was 503.The average number of visits on Spray days was 613 while the average number on non-spray days was 640.9. This difference was not statistically different.

The influence of the weekend on the number of visits to the emergency departments was marked. To control for the effect of the weekend, the number of visits on a spray weekend was compared to the number of visits on non-spray weekends. The average number of visits on a spray weekend day was 652 while on a non-spray weekend day it was 724.

A 10 per cent sequential sample of the emergency department visits resulted in a review of 3,517 records. The residence of the patients, as determined by the postal code, was outside the spray zone for 2,473 and in the spray zone for 1,044. The overall ratio of non-spray zone patients to spray zone patients was 2.4:1. The pattern of a greater number of visits on weekends while

present, particularly for residents of the spray area, was not as pronounced. Table 1 summarizes the average number of visits which occurred. The average number of visits during non-spray days was not different from the average number of visits on spray days. Similarly no difference was found when the number of visits on a spray weekend was compared to the number of visits on a non-spray weekend.

Of the 3,517 patients in the 10% sample 1625 were females and 1891 were males. The sex of one patient was not recorded. The ratio of females to males was not different when patients from spray areas were compared to non-spray areas.

The age range of the 10% sequential sample extended from 2 weeks to 101 years. The mean age for patients coming from non-spray areas was 34 while from spray areas it was 33.6.

Over the 53 day span approximately 3,000 medical records were reviewed to determine if the patient experienced any of the "of interest" problems. Of this group, 1,839 had a discharge diagnosis referable to the eyes or respiratory tract or otherwise consistent with the list of diagnoses described in the methods section. The majority, 1,352, were for respiratory problems. One hundred eighty three (183) had eye complaints, 25 had an unexplained fever, 60 with an unexplained allergic reaction, another 100 had a rash and 119 had a nosebleed.

The respiratory conditions were reported as asthma in 536 patients, bronchospasm or wheeze in 33, pneumonia in 147, bronchitis in 205, an upper respiratory tract infection in 287, a viral illness in 13 and an exacerbation of chronic obstructive lung disease in 81. The remainder had a variety of respiratory diagnoses.

Of the patients with eye complaints 4 were identified as having corneal ulcers. Three of the four were females, two had a residence within the spray zone but neither presented at the time of spraying. One of the remaining two presented at the time of spraying. One of the four was a contact lens wearer. All were discharged home and cultures were not obtained on any.

As with the total visits the number of "of interest" visits to the emergency departments with problems was greatly influenced by the day of the week. Figure 2 graphically represents the number of visits for any of the "of interest" conditions . The average number of visits for any of the "of interest" conditions on spray days was 27.3 while on non-spray days it was 25. This difference was not statistically significant. When only the visits on weekends were considered the number was 35.5 on a spray weekend versus 32.8 on non-spray weekends.

Asthma was the presenting problem for 10 patients on each on the spray days and for 10.1 patients on the non-spray days. When the area of residence was considered, the number of asthma visits from people residing inside the spray area was 2.9 per spray day and 2.6 per non-spray day.

The frequency with which eye complaints presented to hospital was the same in the spray and non-spray periods. There were 3.4 visits per day during the spray periods and 3.5 per day on the non-spray days.

The number of presentations to the emergency department with a complaint of fever was on average less than one per day. In the spray period there were 0.8 visits per day while during the non-spray period the number of visits was 0.5 per day.

The number of patients admitted with allergies was 1.1 during both the spraying and non-spraying days.The mean number of visits for a complaint of a rash was 1.8 during the spray period and 1.9 during the non-spray period. Finally nosebleeds which presented to the emergency department was 2.5 per day during spray periods and 2.2 per day in the non-spray periods. In all these comparisons the differences were not statistically significant.

The ratio of non-spray area to spray area resident in the group identified as having the "of interest" conditions was 2.6:1. This ratio is similar to the ratio found in the sequential sample.

The ratio of female to male in the "of interest" group was 876:958 The sex ratio by area of residence did not change.

The mean age was 26.9 years with the range extending from two weeks to 101.7 years. The group of patients who had a postal code within the spray

zone had a mean age of 25.2 while the group whose postal code placed them outside the spray area was 27.5.

The total number of admissions to hospital was 211. One hundred ninety eight of the patients admitted to the emergency department with a respiratory problem were admitted to hospital. The range of visits extended from none through to 10 in one day. The mean number of respiratory visits on a spray day was 4.5 while on a non-spray day it was 3.5. When only visits on weekends were compared there were 5.2 visits/day on spray weekends compared to an average of 4.2 visits/day on non-spray weekends. These differences were not significantly different.

The number of admissions to hospital following presentation to the emergency department with the problem of asthma was 88. The average number on spray days was 1.8 and the average number on non-spray days was 1.6.

When comparisons were made between pre and post spray periods for the "of interest" conditions the average number of visits during the pre-phase was 32.9 per day and during the post-phase it was 35.2 per day. For patients from the spray area the number of daily visits in the pre-stage averaged 8.1 while in the post-phase it was 10.4. The differences were not statistically significant.

Discussion

A pattern of increased visits to emergency departments on weekends was evident. This pattern was present for all groups but it was attenuated when visits by spray area residents were examined. The pattern did not change when aerial spraying occurred.

When comparisons were made between the number of visits on spray days versus the number on non-spray days significant differences could not be found. Differences could not be found when pre spray admission rates were compared to post spray rates. Similarly when only visits for those whose area of residence was within the spray zone were considered, the pattern persisted and statistically significant differences were not present.

Explanations for not finding differences in the frequency of visits between the two periods are many. The first and the most obvious is that there was no change in pattern. Support for this conclusion is the apparent lack of concern in areas where aerial spraying has occurred in the past. Though formal studies have not been published on emergency room visits it is probable, that if there was a consistent effect, the effect would have been noticed, studied and published.

A second explanation is an effect was present but was so small that it could not be statistically measured in this time frame. In general the smaller the effect, the larger the number of observations required to demonstrate statistically that a change did occur.

The lack of a demonstratable effect on visits should not be interpreted as there not being any effects from the spray program. It is possible the people in the spray zone experienced more symptoms than did those in the non-spray zone but the symptoms were not severe enough to warrant going to an Emergency Department. It is possible that severe effects could have occurred, but at a very low frequency which would make it difficult to demonstrate.

Methods

Visits to the Emergency Departments of six hospitals in the Greater Vancouver region for the period April 13, 1992 to June 4, 1992 were reviewed. The information collected for each day included: the total number of visits, and the age,sex, and postal code for every 10th admission. The day books in each department were reviewed by one of two research assistants (both nurses) to identify patients with respiratory problems, conjunctivitis, corneal ulcers or problems which might be associated with a sensitivity reactions. During the initial period of reviewing the day books the research assistants worked together to develop a common list of problems and/or complaints which would result in further review. Once patients were identified as possibly having a condition of interest their emergency medical chart was obtained. Each chart was reviewed to determine the discharge diagnosis, the patients age, sex, postal code, and time of admission. Information was

also obtained on whether cultures were obtained and whether or not the patient was admitted to hospital or discharged home. This data was abstracted onto a predesigned form and was subsequently entered into a microcomputer.

The respiratory conditions included in the review included asthma, pneumonia, bronchitis, upper respiratory tract infections, and exacerbations of chronic obstructive pulmonary disease. Conjunctivitis and corneal ulcers were the two problems regarding the eyes that were reviewed. Patients with allergic reactions or a rash were included if no obvious reason for the reaction was noted in the chart. Patients with a fever, which could not be explained by any physical or laboratory signs at the time of admission to the emergency department were included. Finally patients with a nosebleed were included if there was no history of trauma.

The postal codes for the spray areas were determined by comparing the maps of the spray areas provided by Agriculture Canada to a Canada Post map of the Forward Sortation Areas (FSA, the first combination of 2 letters and one number) for the region. For the FSA straddling the spray zone the Local Delivery Unit (LDU) were obtained from the British Columbia Department of Finance. The postal code of the patients was compared to the postal codes of the spray zone to determine whether the patient resided in or out of the spray zone.

The dates of spraying were obtained from Agriculture Canada.

Comparisons of spray days versus non-spray days were of two types. In the first all days in which spraying did not occur were called non-spray days. In the second set of comparisons the non-spray days were categorized as either pre spray or post spray. The post spray period was defined as the 5 days after a spray period plus the days between spraying during the first spray interval. All other non-spray days were considered as pre spray.

Analysis used Odds ratios, T test, chi square and ANOVA as appropriate.

Table 1

The mean number of visits to Emergency Departments by spray area and non-spray area residents.

Group	Spray Area (mean)	Non-spray Area (mean)	Total (mean)
Sequential			
spray days	20.1	45.1	65.2
non-spray days	19.6	47.1	66.7
"Of interest" *			
spray days	10.0	26.5	36.5
non-spray days	9.4	24.7	34.2
Respiratory			
spray days	7.4	19.9	27.3
non-spray days	6.3	18.6	24.9

* See text for explanation of "of interest"

Figure 1

FREQUENCY OF DAILY VISITS
FOR RESPIRATORY & EYE PROBLEMS
# of Admissions
70
60
50
40
30
20
10
0
4/13
4/15
4/17
4/19
4/21
4/23
4/25
4/27
4/29
5/1
5/3
5/5
5/7
5/9
5/11
5/13
5/15
5/17
5/19
5/21
5/23
5/25
5/27
5/29
5/31
6/2
6/4
Weekend
Spray Day

Figure 2

TOTAL VISITS TO
SIX EMERGENCY DEPARTMENTS
# of Admissios
900
800
700
600
500
400
0
4/13
4/15
4/17
4/19
4/21
4/23
4/25
4/27
4/29
5/1
5/3
5/5
5/7
5/9
5/11
5/13
5/15
5/17
5/19
5/21
5/23
5/25
5/27
5/29
5/31
6/2
6/4
Weekend
Spray Day

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